⑲ Europäisches Patentamt
European Patent Office
Office européen des brevets

⑪ Publication number: **0 257 670**
A1

⑫ # EUROPEAN PATENT APPLICATION

㉑ Application number: 87201324.8

㉒ Date of filing: 13.07.87

⑤① Int. Cl.⁴: C25D 5/06 , C25D 7/10

③⓪ Priority: 19.07.86 GB 8617675

④③ Date of publication of application:
02.03.88 Bulletin 88/09

⑧④ Designated Contracting States:
AT DE ES FR IT

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⑤④ **Process and apparatus for the deposition of bearing alloys.**

⑤⑦ A process and apparatus is described for the electro-deposition of an overlay alloy onto a bearing alloy surface (14). The process comprises the steps of cleaning the surface, providing relative motion between the surface to be plated and a porous pad (52) in contact with said surface, providing a flow of plating solution to the porous pad and said surface whilst applying a voltage difference between said surface which is cathodic during overlay deposition and an anode (51) connected to the porous pad. An example of the deposition of a tin-based overlay alloy containing cobalt is described.

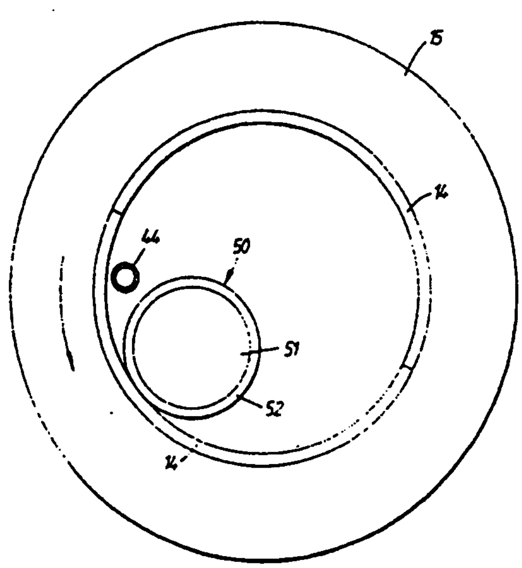

FIG. 3.

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PROCESS AND APPARATUS FOR THE DEPOSITION OF BEARING ALLOYS

The present invention relates to alloys suitable for bearing applications and particularly to a process and apparatus suitable for depositing such alloys.

Where overlays have been applied to bearings by electroplating techniques they have conventionally been applied by plating in well-known plating vats or baths with the bearings being totally immersed in the plating solution.

Particular problems arise in the deposition of overlay alloys on aluminium alloys as distinct from other bearing alloys such as those based, for example, on copper.

Most plating of overlays comprising, for example, lead or tin-based alloys has been carried out either in fluoroborate plating baths which are highly acidic in nature or in other, also highly acidic, plating solutions. Such plating methods involve a lengthy series of process steps. Firstly the bearing surface must be cleaned and provided with what is normally known as a zincate layer to inhibit reoxidation of the cleaned aluminium alloy surface and to promote adhesion of the subsequent interlayer. An interlayer, often of nickel, copper or an alloy based on one of these metals is plated on top of the zincate layer. The primary purpose of the interlayer is to protect the zincate layer from corrosive attack by the fluoroborate or other acidic plating solution from which the overlay alloy is to be deposited.

This plating sequence brings with it its own specific problems. The principal problem of these relates to the interlayer. There is evidence to suggest that the presence of the interlayer tends to render a bearing more seizure-prone when the co-operating shaft wears through the overlay. A further problem also related to the interlayer concerns the change in alloy composition of the deposited overlay. Where, for example, lead-10% tin is plated onto a nickel interlayer a diffusion effect at engine operating temperatures tends to cause depletion of tin in the overlay by reaction with the nickel. The effect of tin depletion is to render the overlay more prone to corrosion. The overall effect of the presence of the interlayer is to render the bearing alloy system unstable over its operational life perhaps even shortening the operational life of the bearing.

Other less acidic plating systems do exist but are very much more expensive; in some cases the cost of the overlay plating solutions may be very high and not commercially viable. Therefore, such plating solutions may be dismissed on the basis of cost alone. It has been found, however, that even where such expensive solutions are used the long term integrity between the overlay and the zincate layer is questionable as corrosion between overlay and zincate layer in hot oil has been observed. Tin and zinc is known to comprise a corrosion couple which has resulted in the complete delamination of the overlay from the zincated aluminium alloy.

A process has now been discovered which permits the direct plating of overlay onto the aluminium or aluminium alloy bearing surface without the need for intervening zincate and other interlayers.

According to a first aspect of the present invention a process for the electro-deposition of an overlay onto an alloy surface comprises the steps of cleaning the surface, providing relative motion between the surface to be plated and a porous pad in contact with said surface, providing a flow of plating solution to the porous pad and said surface whilst applying a voltage difference between said surface which is cathodic during overlay deposition and an anode connected to the porous pad.

The method is generally known as brush plating but has in the past only been used for the plating of selected areas of a component or for localised repairs and not for the provision of a uniform thickness of overlay on the surface of an aluminium or chromium alloy bearing.

Relative velocity between anode and surface being plated preferably lies within the range 0.05 to 2 $m.sec.^{-1}$ and more preferably in the range 0.1 to 1 $m.sec.^{-1}$.

The porous pad may comprise a covering on the anode.

The method has proved to show unexpected benefits in the plating of overlays onto aluminium-based bearing alloys. It has been unexpectedly found possible to deposit overlays directly onto the aluminum alloy substrate without the need for pre-treatments such as zincating and, therefore, without the need for interlayers such as nickel etc. Furthermore the method of the present invention reduces the number of cleaning stages to two instead of six as in a conventional plating bath method. This latter benefit clearly has important consequences on the size and cost of the plating plant required and also on the actual processing costs.

According to a second aspect of the present invention apparatus for the electro-deposition of an overlay onto the surface of a bearing comprises means for holding one or more bearings, an anode, a porous material interposed between the surface and the anode, the porous material contacting the surface of the bearing to be plated, drive means to provide relative movement between the surface of

the bearing to be plated and the anode, means to render the bearing surface cathodic with respect to the anode and means for supplying plating solution electrolyte to the cathodic and anodic surfaces.

In one embodiment of apparatus according to the present invention the bearings may be held in cylindrical pairs and rotated about their axis.

The electrolyte may be supplied to the outside of the porous material or may be supplied by passing through the material from the inside, for example, via the anode itself.

The anode may be cylindrical and mounted on a swinging arm which biasses the anode against the bearing surface to be plated.

It has been found that when plating relatively soft alloys of the kind often employed for bearing overlays that a soft, porous textile material is preferable. An example of such a suitable type of material is that sold under the trade name of Selvyt cloth.

In order that the invention may be more fully understood some examples will now be described with reference to the accompanying drawings of which:

Figure 1 shows a schematic part sectioned view of apparatus according to the present invention set up to brush plate pairs of half bearings;

Figure 2 shows a part sectioned side view through one of the plating tanks of Figure 1 and its associated apparatus;

Figure 3 which shows a schematic general arrangement of the bearings to be plated and the plating electrodes etc.

Referring now to the drawings and where the same features are denoted by common reference numerals.

The apparatus comprises a clean and etch tank denoted generally at 10, wash tanks denoted generally at 11 and 12 and a brush plating tank denoted generally at 13. Bearings to be plated 14 are held in a jig 15 which is mounted on a plate 16 which is itself fixed to a shaft 17 of a motor 18. The motor 18 is mounted on threaded shafts 19 which are adapted to move the motor 18 and bearing jig 15 in a direction parallel to the axis of the motor shaft 17. The threaded shafts 19 are themselves part of a gantry 20 having grooved wheels 21 which co-operate with rails 22 which support the gantry 20 for transverse motion with respect to the row of tanks 10, 11, 12 and 13. The gantry 20 is moved along the rails 22 by a chain drive 23 which is controlled by sprockets driven by an electric motor (not shown) having known control means (not shown). The motor 18 is moved parallel to the direction of the shaft 17 by means of the threaded shafts 19 which co-operate with threaded holes in a mounting block 30. The motor is moved by rotation of the shafts 19 which are driven by pulleys 31 and 32 linked by a toothed belt 33, the pulley 32 being driven by an electric motor 34 having known control means (not shown). The clean and etch tank 10 and the plating tank 13 and their associated systems comprise lower collector troughs 40 and upper splash guards 41. Clean and etch or plating solutions are supplied to the tanks 10 and 13 from reservoirs 42 pumped at a controlled rate by peristaltic pumps 43 through conduits 44. Used solutions are returned to the reservoirs 42 from the collector troughs 40 via drain conduits 45, pumps 46 and refrigeration units 47. Solutions are supplied via the conduits 44 to a cylindrical plating brush 50 which comprises a central core 51 of graphite forming the anode the graphite being covered with a sleeve 52 of Selvyt cloth (trade mark). The anode may also comprise non-reactive metals such as, for example, platinum. The brush 50 is mounted on a swinging arm 53 which is pivoted on a shaft 54 held in a support pillar 55. Connected to the swinging arm 53 and brush 50 via the pivot shaft 54 is a motor and clutch unit 56 adapted to move the brush 50 through an arc to bring it into contact with the bore of the bearings 14 to be plated at a controlled load. The wash tanks 11 and 12 have lower collector troughs 60 and upper splash guards 61. The troughs 60 have drain conduits 62 connected to a manifold 63 to take away waste water. Clean wash water is supplied from a pump 64 via a manifold 65 to conduits 66. Water is allowed to access the bearings 14 through conduits 67 by operation of solenoid valves 68. Suitable electrical contacts 70 are provided to make the bearing surface cathodic. A known power supply 71 is also provided to control both voltage, current and time; the power supply 71 also has the facility to change polarity of the electrodes.

Operation of the above apparatus will now be described in relation to the deposition of a tin-cobalt overlay onto an aluminium-20 wt% tin-1 wt% copper bearing alloy. Bearings 14 of 53mm dia and 30mm length and comprising a steel backing having the stated aluminium alloy thereon were degreased in trichloroethylene and loaded into the jig 15 in three sets of two pairs effectively forming a cylindrical tube of bearings. The jig 15 was then assembled onto the plate 16 of the motor 18. With the mounting block 30/motor 18 at the furthest extent of its travel to the left on the threaded shafts 19 the gantry 20 was traversed along the rails 22 until the jig and bearings were opposite tank 10. The bearings 14 were then advanced into the clean and etch tank 10 to allow penetration of the brush 50 into the jig 15. The bearings were then rotated at 120 rev./min. with the bearings anodic at 9 volts whilst 10% hydrochloric acid was pumped into the region where the bearing surface and Selvyt cloth contacted. This was continued for 2 minutes at a

current of about 8 amps. The polarity of the bearings was then reversed to cathodic and the process repeated for a further 2 minutes under the same conditions.

The bearings were then withdrawn from the tank 10 and the gantry 20 advanced to the wash tank 11 where they were rinsed with clean water with the bearings rotating at 40 rev./min. The bearings were then advanced to the plating tank 13 where they were plated with a Sn-Co overlay. The plating solution used comprised 50 gm/lit stannous sulphate, 40 gm/lit cobalt sulphate, 50 gm/lit sodium heptonate and the pH was adjusted to 2 by means of acetic acid. The jig and bearings were rotated at 120 rev./min. with a plating solution flow of approximately 0.2cm $^{3-1}$sec. and a brush pressure of approximately 20 gm/cm^{-2}. The bearings were cathodic at a potential of about 15v with an initial current flow of 8A rising to about 16A. The bearings were plated for a time sufficient to deposit between 20 and 25 um of overlay. The bearings were then rinsed in tank 12 and dried.

The resulting overlay possessed an average of 8% Co in the Sn matrix.

The resulting plated bearings were tested in a known "Sapphire" testing machine which measures the fatigue rating of the overlay. The testing schedule comprised the following procedure and conditions:

Shaft speed 2800 rev./min.
Initial load 62 MPa
Load increased after 20 hours at each load by 7 MPa until failure
Oil temperature 80°C
Sinusoidal load pattern

Test results of 97, 103, 103, 90 and 90 MPa were obtained on the bearings produced by the method described.

Further bearings were produced with an additional surface treatment of a zincate layer on the aluminium alloy but without an additional interlayer. Fatigue test results on the "Sapphire" machine gave ratings of 62, 62 and 76 MPa demonstrating an adverse effect of the zincate layer.

For the purposes of comparison the same Al-20Sn-1Cu alloy overlay plated with a known Pb-10Sn overlay by a known conventional immersion plating method in a fluoroborate-type bath with zincate and nickel interlayers gives a fatigue rating typically in the region of 70 MPa on a "Sapphire" test rig.

In the above the bearings are themselves rotated, however, it will be appreciated that the anode may be rotated instead or in addition.

The electrolyte may be supplied into the plated surface and anode gap or via the anode itself.

It is envisaged that the method of the present invention could be applied to the plating of continuous strip with overlay. The overlay coated strip may then be processed into bearings by known techniques. Such a process may alleviate one of the most serious drawbacks of the plating of bearings which is the labour intensive and, therefore, costly step of jigging and dejigging bearings before and after plating.

The method of the present invention may be applied to many other overlay metals and alloy systems, examples of which may include Pb-Sn, Pb-Sn-Cu, Pb-Sb, Sn-Sb, Sn-Ni, Sn-Cd, Sn, Sn-Cu, Pb, Pb-In, In, Sn-In, Sn-Sb-Cu, Cd-Ni.

Claims

1. A process for the electro-deposition of an overlay onto an alloy surface characterised by the process comprising the steps of cleaning the surface, providing relative motion between the surface to be plated and a porous pad (52) in contact with the surface, providing a flow of plating solution to the porous pad and the surface whilst applying a voltage difference between the surface which is cathodic during overlay deposition and an anode (51) connected to the porous pad.

2. A process as claimed in Claim 1 characterised in that the alloy surface is an aluminium alloy.

3. A process as claimed in Claim 1 or Claim 2 characterised in that the plating solution is supplied through the porous pad.

4. A process as claimed in any one preceding claim characterised in that the plating solution is supplied via the anode.

5. A process as claimed in any one preceding claim characterised in that the velocity of relative motion between the alloy surface and said porous pad lies in the range from 0.05 to 2m.sec.$^{-1}$.

6. A process as claimed in any one preceding claim characterised in that the velocity lies in the range from 0.1 to 1m.sec.$^{-1}$.

7. A process as claimed in any one preceding claim characterised in that the alloy surface to be plated is substantially cylindrical.

8. A process as claimed in any one preceding claim characterised in that the overlay comprises tin and cobalt.

9. A process as claimed in any one preceding claim characterised in that the surface to be plated is the surface of a bearing alloy.

10. A process as claimed in Claim 9 characterised in that the bearing alloy is in flat strip form.

11. A process as claimed in Claim 9 characterised in that the bearing alloy is in cylindrical or semi-cylindrical bearing form.

12. Apparatus for the electro-deposition of an overlay onto the surface of a bearing characterised in that the apparatus comprises means (15) for holding one or more bearings (14), an anode (51), a porous material (52) interposed between the bearing surface and the anode the porous material contacting the surface of the bearing to be plated, drive means (18) to provide relative movement between the surface of the bearing to be plated and the anode, means to render the bearing surface cathodic with respect to the anode and means (43) for supplying plating solution electrolyte to the cathodic and anodic surfaces.

13. Apparatus as claimed in Claim 12 characterised in that the porous material is a covering over the anode.

14. Apparatus as claimed in either Claim 12 or Claim 13 characterised in that the material is a soft textile material.

15. Apparatus as claimed in any one of Claims 12 to 14 characterised in that the anode is cylindrical.

16. Apparatus as claimed in any one of Claims 12 to 15 characterised in that the bearings are held in cylindrical pairs and are rotated about their axes by drive means.

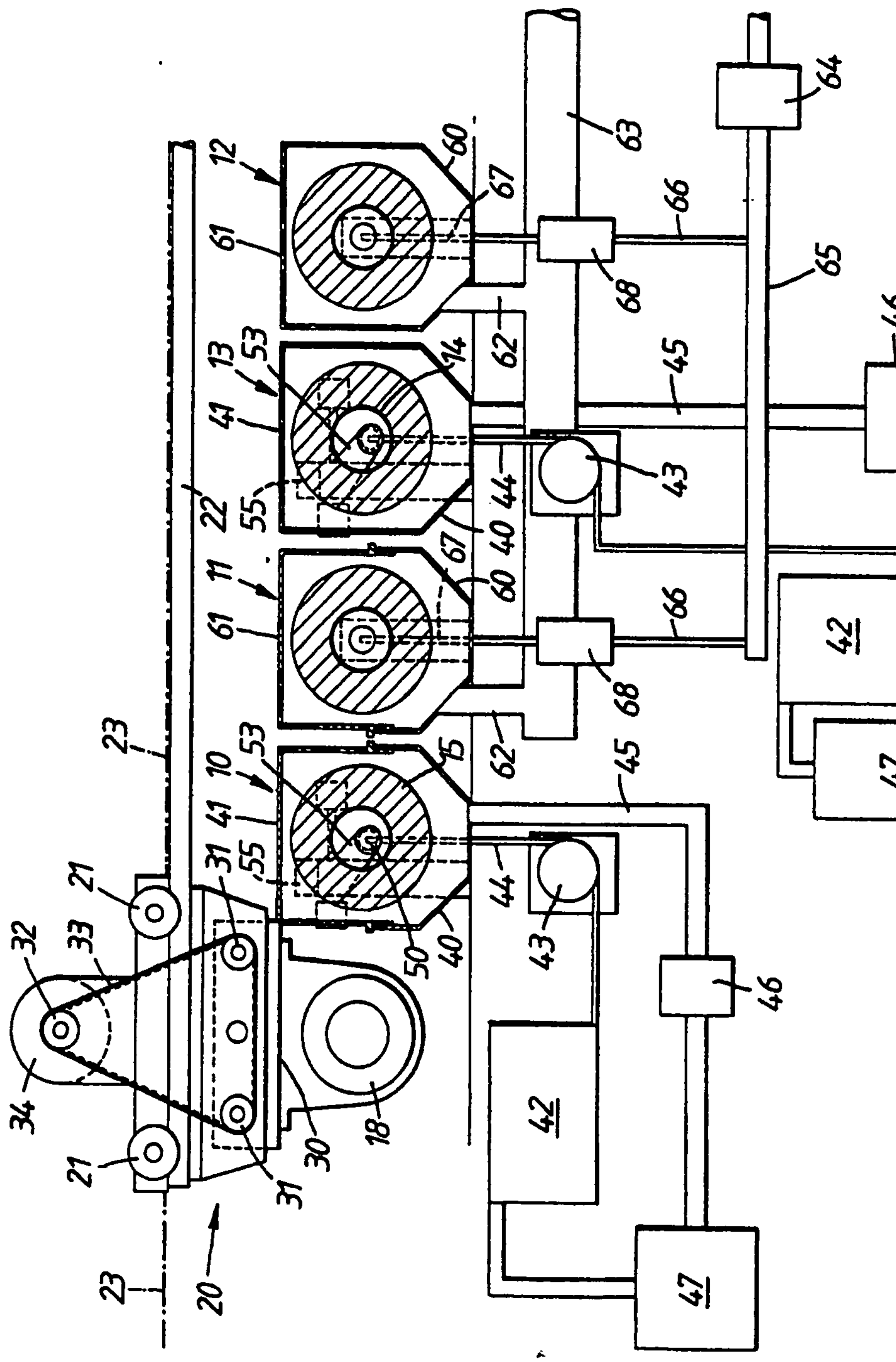
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FIG. 1.

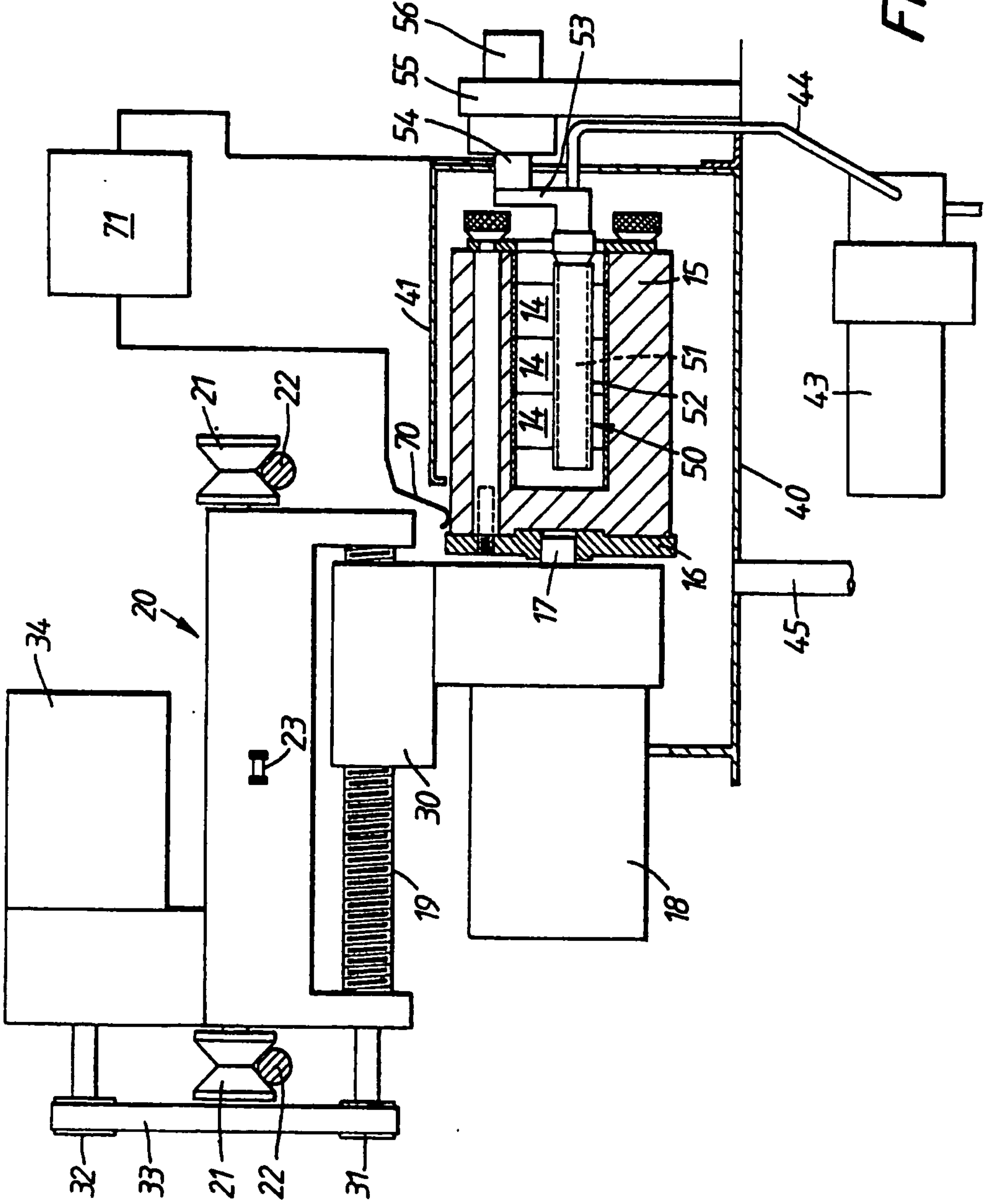
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FIG.2

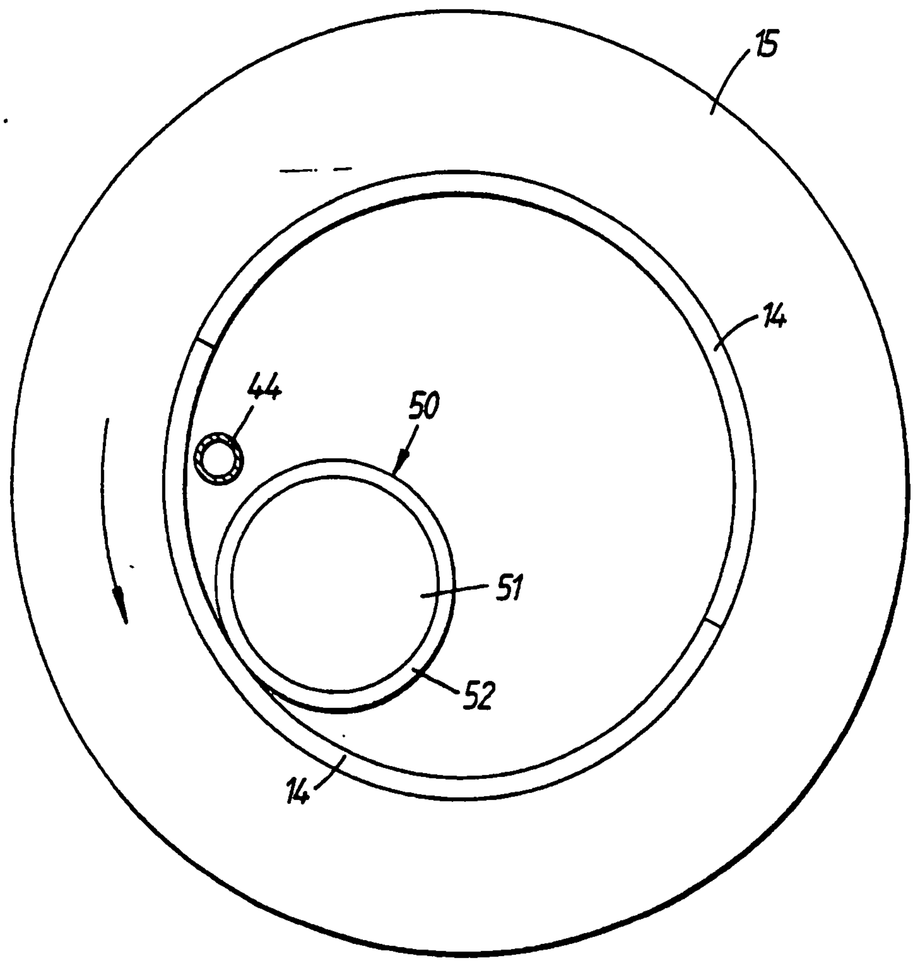

FIG. 3.

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EUROPEAN SEARCH REPORT

Application number

EP 87 20 1324

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	GB-A-2 102 836 (IMPERIAL CLEVITE) * Page 2, lines 17-34,119-130; page 3, lines 1-3 * ---	1,3,4, 5,7,9, 11-16	C 25 D 5/06 C 25 D 7/10
X	GB-A- 760 016 (THE GLACIER METAL CO.) * Figures 6,7 * ---	1,3,5, 7,9,10 -14	
X	DE-A-3 312 905 (BATTELLE) * Page 4, line 11; page 7, lines 1-6 * -----	1,3-5, 9,11- 16	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

C 25 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02-09-1987	NGUYEN THE NGHIEP

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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